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Open Roads Public School

2012 Submission for Awards of Excellence

MCW

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Keewatin Patricia
DISTRICT SCHOOL BOARD

LM Architectural Group

Open Roads Public School
Dryden, Ontario

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Open Roads Public School
Dryden, Ontario

Project Highlights

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APPLICATION OF TECHNOLOGY

The Keewatin Patricia District School Board continues to lead the way in supporting and implementing new, cutting edge sustainable building strategies. Several technologies implemented in this design, although considered cutting edge by other owner groups, have become quite common place with the KPDSB. For that reason, they are continuing to think out of the box with respect to sustainability.

1. Displacement Ventilation – Introducing ventilation air at low level and low velocity, and returning at high level reduces the amount of ventilation and cooling air required for the classroom. This strategy saves fan energy at the air handling unit, reduces the demand on heating and cooling equipment, as well as reducing air noise from the ductwork and diffusers.
2. Desiccant Wheel Technology – Each of the two air handling units which provide ventilation air to the school employ desiccant wheels which reduce the humidity in the air prior to the air passing through the cooling coil. Normally, the cooling coil is responsible for reducing the relative humidity of the supply air by drastically reducing the temperature, and therefore forcing the moisture in the air to condense and often causing such low air temperatures that it needs to be reheated. By using the desiccant wheel, we reduce the relative humidity prior to entering the cooling coil without lowering the temperature. The school's chiller capacity was reduced by 30% as a result.
3. Condensing Boilers providing both Heating Water and Hot Domestic Water – The high efficiency condensing boilers have an integral heat exchanger allowing them to provide both heating water to heat the building, and domestic hot water for sinks, and lavatories. The result is less equipment, as a separate hot water tank is no longer required as well as higher efficiency, due to the fact that there is no storage losses associated with having a separate hot water tank. Traditional atmospheric hot water tanks have an average efficiency of approx. 65%. Utilizing this method, we are able to take advantage of the boilers high efficient operation and achieve an efficiency of over 94%.
4. Band Room Design – The band room was engineered using acoustic design modeling software to optimize the acoustic environment. Wall and material selection were carefully designed to control reverberation and optimize the rehearsal environment, and mechanical systems were acoustically isolated to reduce breakout and break-in noise.
5. Demand Control Ventilation-Ensures that ventilation air is introduced to the occupied spaces only as required. When a classroom is empty, or lightly populated, the air volumes can be scaled back, reducing demand on heating, cooling and ventilation equipment. Conversely, when more fresh air is required in a particular area, the room's highly intuitive DDC control system allows for the introduction of higher quantities of fresh outdoor air.

SOCIAL / ECONOMIC / ENVIRONMENTAL IMPACT

1. Each of the building's mechanical and electrical systems was designed with the highest level of sustainability and energy efficiency in mind. This results in a performance level which greatly exceeds both the Ontario Building Code as well as the Model National Energy Code for new buildings. The result is reduced operating costs with increased equipment longevity. Energy consumption during the first year of operation is half that of traditionally constructed schools in the division.
2. The school is multi-cultural and the architects ensured many First Nations cultural elements were incorporated in the design. Stained glass portions of the student commons windows represent the medicine wheel. Animal representations of the Seven Teachings are carved in the concrete floor in several locations. Two grade 6 students from the school entered a contest and were selected to hand paint a cultural design in the centre of the gym floor.
3. Educational themes are incorporated into the school's website explaining the energy saving measures incorporated and the real life impact which results from their incorporation.
4. Incorporation of various cultural and accessibility elements allow the student population to learn in an extremely cohesive, engaging and comfortable environment.

COMPLEXITY

Because this project was intended to be a replacement of three existing schools, schedule commitments were made very early on in the construction. Students attending the now surplus schools had nowhere to go should the Open Roads School not be ready for the 2011/2012 calendar year. There was no 'Plan B.' Added to the compressed schedule, was the fact that several of the mechanical and electrical design elements had never been attempted in the area previously. Learning curves and deliveries of fairly custom equipment threatened to derail the ambitious schedule on numerous occasions. Close coordination and communication between all Contractors, Owners, Architects and Engineers involved successfully sidestepped any serious scheduling issues, and the students were able to enjoy their new space at the start of the new school year.

OWNER'S NEEDS

The new Open Roads School has exceeded the Owner's expectations on many levels and proven to be an exciting and enjoyable learning space for all students. Aside from being a comfortable and engaging learning space, the incorporation of the educational elements of the sustainable design makes the Open Roads School an important educational tool in its own right.

Open Roads Public School
Dryden, Ontario

Full Project Description

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Open Roads Public School
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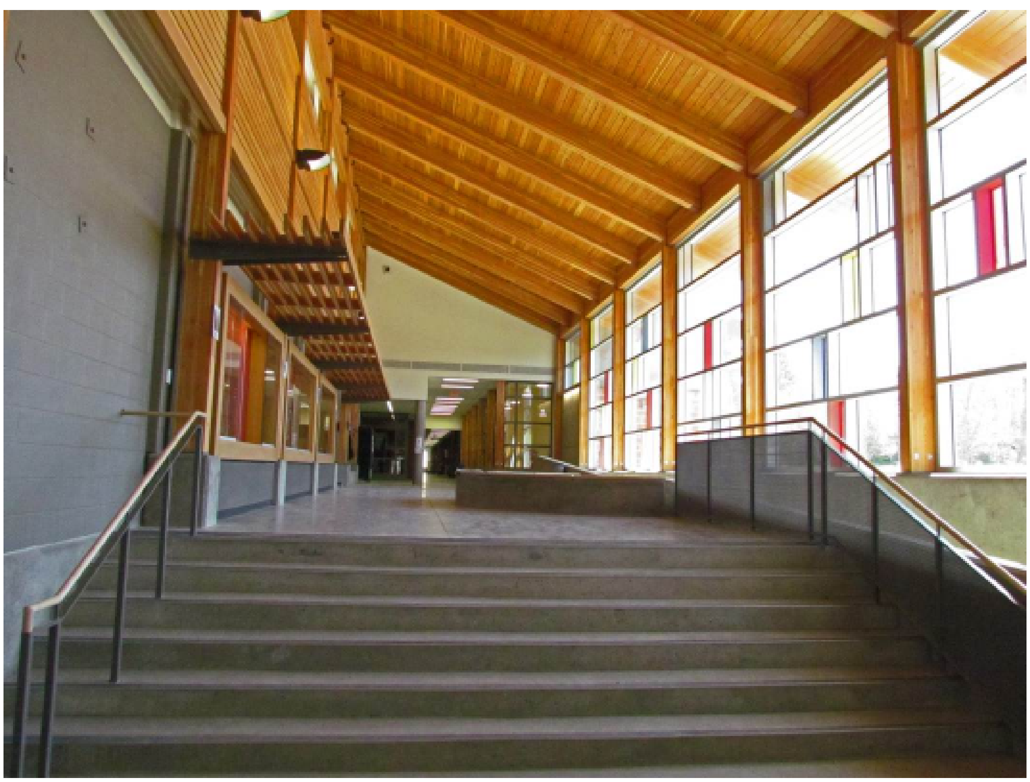
Introduction

As good as a school division's maintenance regime may be, the time comes when a school exceeds its useful or cost effective life cycle. When this occurs, the school is considered "prohibitive to repair," meaning that the operating cost and capital repair costs no longer make fiscal sense. Such was the case for three of the Keewatin Patricia District School Board's schools in Dryden, Ontario. A new school would need to be built. An added consideration was the changing student demographic in the area.

After extensive programming and population projection analysis, Open Roads School (at the time named "The New Dryden K-8") began its journey to fruition.

The Keewatin Patricia District School Board is an extremely forward thinking and aggressively "green" school division. As such, the newest school in their inventory would need to be state of the art in terms of energy efficiency, technology and sustainability, and reflect the sustainable principals which the Dryden area's First Nations people hold dear. Many aspects of the school's design are based upon traditional First Nations beliefs and culture, from the extensive use of natural wood and natural light to the colours of the medicine wheel represented in stained glass. The design team of MCW/AGE Consulting Professional Engineers and LM Architectural Group would surely have their work cut out for themselves.



Stained glass portions of the Student Commons windows represent the medicine wheel.

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Building Envelope

More and more, building envelope (walls, windows and doors) systems are an integral part of any building construction. Walls must be constructed to maximize thermal resistance and minimize infiltration, or air passing through. Windows must be selected to both allow the appropriate amount of necessary daylight, as well as reduce both solar gain and outward heat transmission. Doors must be selected to minimize heat loss and seal out cold drafts.

The new school would see extremely efficient envelope design, exceeding the current building code standards. One concept which garnered much debate was the decision to include sealed windows throughout the building; no operational windows would be included in the design. This placed extreme reliance on the HVAC system to provide stellar performance and reliability. If the HVAC system did not perform well, there would not be the option to open a window to provide additional ventilation.

Performance level of Open Roads Public School greatly exceeds both the Ontario Building Code and Model National Energy Code.

Mechanical Systems Introduction

Once the building envelope standards were selected, the mechanical systems design began. This particular school division is extremely forward thinking in terms of sustainability and energy efficiency. The newest technologies are constantly being investigated for implementation in new or renovated schools.

Some tried and true elements for KPDSB, which some other user groups may consider new and untested, continued to be implemented in this design as well as a few which were "out of the box" even for them. Careful research, discussion and analysis resulted in the combination of old and new strategies.

Mechanical Systems Selection

The Keewatin Patricia District School Board, being extremely ambitious towards sustainability and reduced utility consumption, expressed their strong desire to incorporate other leading edge strategies for heating and cooling the school. The following selections were a result of extensive discussion and research:

- Condensing boilers
- Combination heating water and domestic water boilers
- Reverse flow heat recovery ventilator (HRV)
- Displacement ventilation
- Demand control ventilation
- Variable frequency drives for fans and pumps
- Low consumption plumbing fixtures
- Air handling units employing desiccant wheel technology
- All-encompassing DDC technology

Condensing Boilers

Condensing boiler technology became mainstream in the early 2000's and relies on the boiler's heat exchanger ability to withstand lower return water temperatures, and reclaiming the energy from latent heat of absorption; normally lost up a conventional boilers chimney. The result is a boiler which is upwards of 98% efficient.

This efficiency is optimized when the return water temperature is 27°C. To achieve this, all heat transfer equipment was sized accordingly; with larger ranges between entering water temperatures and leaving water temperatures (Delta T), and a lower initial supply temperature.

The loss of heat through the walls and roof (skin loss) is accounted for by radiant heating tubes located in the poured concrete floor. This allows for low return water temperatures, maximizing the boilers' efficiency, as well as reducing the energy required to pump the thermal fluid. The larger the "Delta T", the lower the flow required to achieve heat transfer from the thermal fluid to the equipment.

Each boiler also incorporates a separate heat exchanger for heating domestic water. On a call for hot domestic water, the boilers internal controls allow flow through the heat exchanger to produce hot domestic water. This arrangement eliminates the need for additional domestic hot water generation tanks and storage tanks, as well as taking advantage of the boilers high efficiency as well as storage losses.

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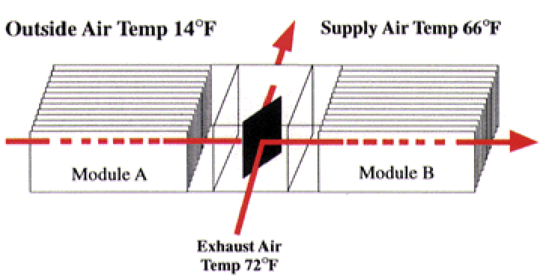
Reverse Flow Heat Recovery Ventilator

In 2005 and the spring of 2006, a new type of air to air heat recovery ventilator (HRV) was being introduced to the Northwest Ontario market. These HRVs effectively captured heat from outgoing exhaust air streams, and transferred it to incoming cold ventilation air. This concept has been in common use for years, but what was unusual about these heat exchangers is how they worked. These units, called Reverse Flow Heat Recovery Ventilators, push the warm exhaust air over a series of thin plates that have a high mass, which warms the plates. Simultaneously, they draw in cold ventilation air across a similar series of high mass plates, which cools them. Every 90 seconds, a damper in the unit changes position and the flow is reversed. The ventilation air is drawn in across the plates that were just warmed by the exhaust air stream thus warming the air; also the exhaust is directed across the cold plates that previously were cooled by the intake air stream. The huge advantage of this system is that it is self-defrosting.

The cold winters in Northwest Ontario are a challenge to most heat recovery ventilators due to moisture in the warm exhaust air condensing and freezing during the heat transfer process. Most heat recovery ventilators overcome this through a process of bypassing air. Unfortunately this means that the cold incoming ventilation air stream is stopped periodically to permit the Heat Recovery Ventilator to defrost. On many economical units this occurs about 20 minutes out of every hour on a cold day. In a building as complex as a school which has many continuous exhausts, interrupting the incoming replacement ventilation air is not an option.

The selected Heat Recovery Ventilator has only one moving part, the damper that reverses the flow of air. Hence it is very simple to understand, detect problems and repair. Refer to Figure 1 for a display of a reverse flow HRV operation.

Figure 1 – Reverse Flow HRV Operation



First Cycle: Warm exhaust heats up Module A. Cold outside air flows through Module B, picking up heat that was stored during the previous cycle.

Second Cycle: The damper shifts. The system now draws cold outside air flows through Module A. Warm exhaust goes to Module B, which recovers energy and stores it for the next cycle.

Demand Control Ventilation

Through the evolution of the design concept, the early stage idea of recovering heat from the exhaust air streams from classrooms was altered to recover heat from relief air. Every occupied building is required to introduce a specific amount of outside air during all occupied periods. This air replaces that exhausted from washrooms, kitchens, and janitor's spaces, but in a facility housing 480 students frequently more air is required to be introduced than is exhausted. This excess air must be removed from the building to prevent over-pressurizing the building envelope. It is this air stream, as well as the washrooms and relatively clean exhausts from the gymnasium change rooms and art rooms that heat is recovered from.

Sensors have been installed in the building to measure how many students are in the facility, so that the quantity of ventilation air can be reduced to the minimum necessary to provide a 'fresh' environment, free of contaminants from people and off-gassing from furniture and building elements such as carpets.

Each classroom has sensors which measure CO_2 levels, temperature, humidity and student occupancy. When a class of children leaves the room for the library, gymnasium, recess, etc., the lack of occupancy is noted and the ventilation air is temporarily suspended to the room easing the burden on the HVAC system. When the children return, the system reverts back to normal occupied operation. The air quality is closely monitored such that if the CO_2 level increases, more fresh air is introduced to improve the air quality.

The volume of incoming and exhaust air is in a state of continuous flux during the day, and the relief air system must also continuously adjust to keep the building pressure neutral. To achieve this the indoor pressure is measured at various locations in the building and the fans that bring ventilation air into the building, and those that remove the relief air are continuously adjusted by altering the fan speed using Variable Frequency Drives (VFD's) on both the supply and exhaust fan motors. This is commonly called Demand Control Ventilation in industry jargon.

Variable Frequency Drives for Fans and Pumps

Unitary equipment such as fans moving supply air and pumps moving heating water are typically sized for maximum capacity of the system based on detailed calculations. For example, the fan in an air handling unit is sized for the air quantity required for cooling; as more air flow is required across a cool surface (cooling coil) than a warm surface to allow heat transfer. In this application, cooling is not required throughout the year, so savings may be achieved by reducing the capacity of the fan, the corresponding air quantity, and therefore energy required, when cooling is not required. When strictly ventilation air or heated air to increase space temperatures is required, fan speed may be reduced by as much as 70%.

Similarly, when a classroom becomes unoccupied during the day for various reasons, the control system recognizes this condition and closes the corresponding VAV box, thus suspending the flow of ventilation air for the period of unnoccupancy. Reduced air flow in the classrooms means that the corresponding air handling unit does not need to supply as much air, and the speed of the supply fan can be reduced (demand control ventilation), saving fan energy.


Air Handling Unit and Variable Frequency Drives for Fans and Pumps

Displacement Ventilation

Most typical ventilation systems in similar buildings utilize mixing technology. This means that large quantities of air are introduced at high level within a room and allowed to mix with the air within the room. This dilutes the air with respect to CO_2, VOC's off gassing from furniture, etc. The resulting mixed air is removed from the room by either exhaust or return air back to the air handling unit.

Displacement ventilation introduces ventilation air at low level, where it migrates at floor level until it meets a heat source such as a person, computer, etc. The air rises as it warms taking with it any contaminants.

Because displacement ventilation requires lower volumes of slightly warmer air than a conventional system, savings can be achieved both due to smaller cooling equipment and less fan power. In this instance, the chiller capacity was reduced by 17 tons. An added benefit is that since the air is discharged into the room at a lower velocity, many of the noise issues associated with rapidly moving air are removed. In fact, the resulting air noise at Open Roads School is non-existent in the classroom. Refer to Figures 2, 3 and 4 for a display of displacement ventilation.

Typical Classroom

Figure 2 – Mixing (Dilution) Ventilation

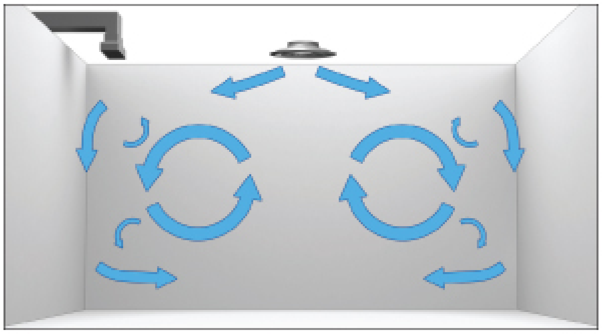


Figure 3 – Displacement Ventilation

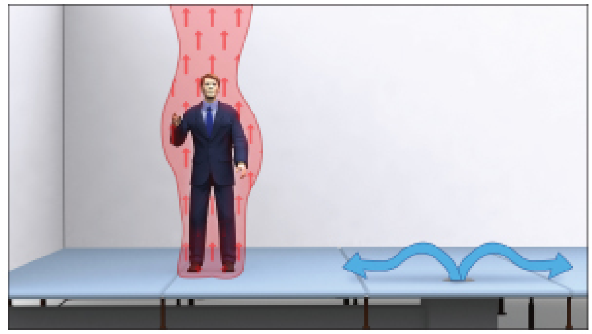
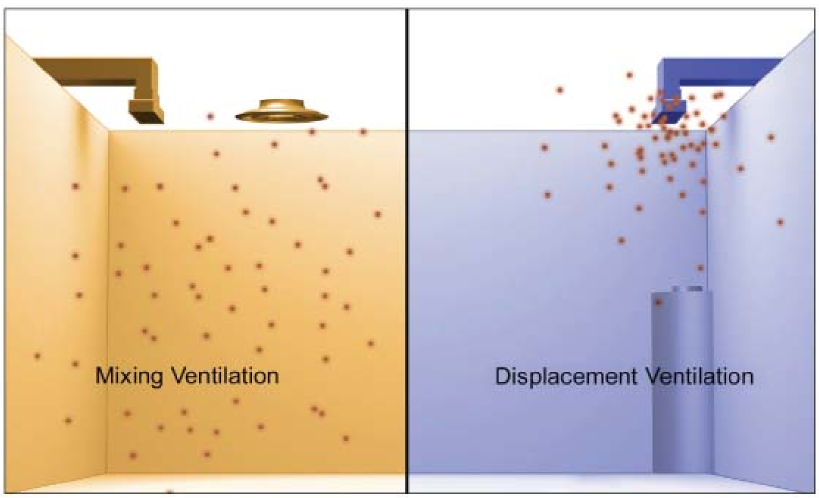


Figure 4: Contaminant Distribution



Uniform distribution of contaminants within the mixed space

Uniform distribution of contaminants within the mixed space

Plumbing Fixtures

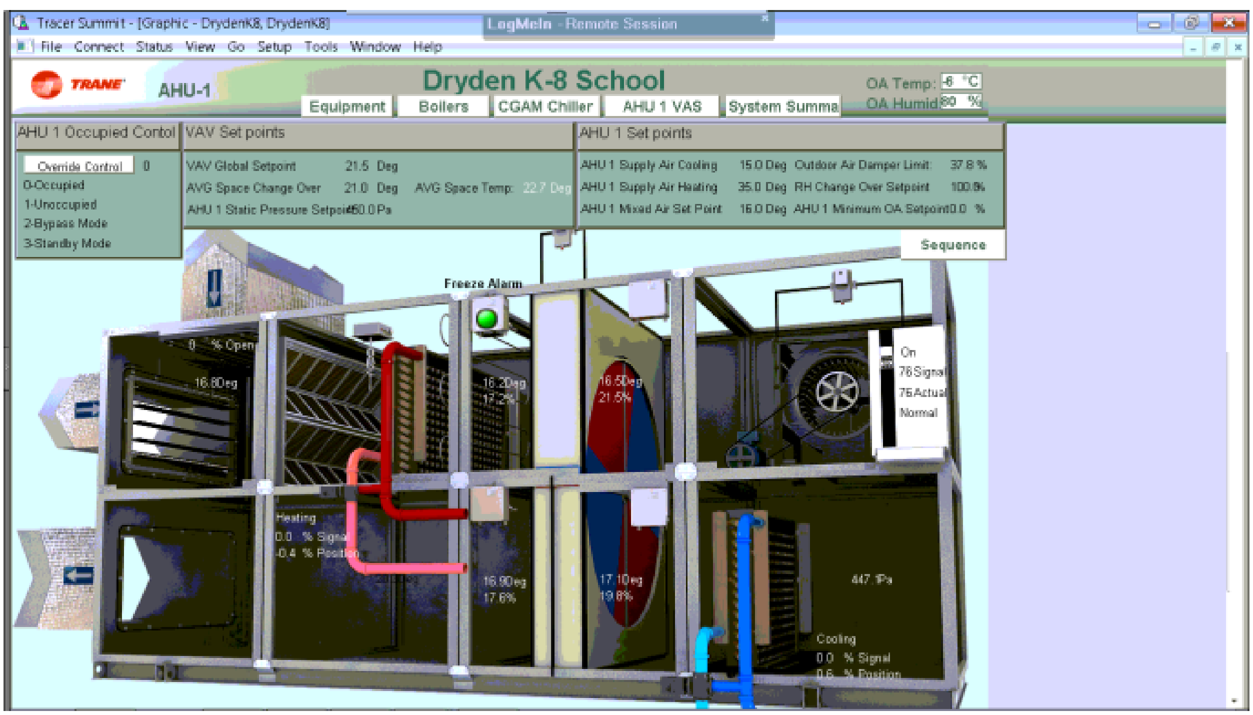
Water conservation is achieved through the use of water conserving plumbing fixtures. All lavatories and sinks are equipped with point of use 1.9 litre per minute (LPM) aerators to limit water flow. All lavatories utilize electronic sensors to limit water flow to the exact length of time hands are under the faucet. The units were specifically selected so that they did not continue to operate, but only for a few seconds after the hands are removed.

Water conserving 6 litres per flush water closets that also utilize electronic sensors were utilized. The urinals are waterless, meaning that no water connection is required to flush. Instead an environmentally friendly chemical is located in the drain which allows the passage of urine, but blocks the odours caused by sewer gas within the piping system. These urinals have the potential to save up to 150,000 litres of water annually.

All-Encompassing DDC Technology

The school utilizes a new generation BacNET DDC (direct digital control) HVAC control system to operate all aspects of the heating, cooling and air conditioning systems, ensuring the highest efficiency possible. From the thermostat on the wall to control the temperature in a classroom, to the sophisticated computer controls of the boiler and chiller plants, every function is fully controlled and closely monitored by the systems microprocessors. In turn, the maintenance staff is kept fully aware of building conditions, and notified immediately should concerns arise through the highly interactive computer graphics. See Figure 5 below. The ability to manipulate and monitor the environment within the school in this manner, means reduced operating costs due to maintenance labor, and even the ability to access and alter system parameters remotely.

Figure 5 – DDC Technology



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Electrical Features

Lighting Controls

The planning and executing of lighting control in a school environment rests largely on the multi-use of today's school for community involvement and multi-function use of space which includes computer classrooms, drama rooms, music rooms, and gymnasium for sports and community gathering. While the building has to provide an ideal learning environment for students it also needs to be flexible as the school may service other functions in the community. In addition the school must operate efficiently, using energy in an efficient manner and leaving the minimal impact on the environment. Lighting controls helped to meet all those challenges.

Automatic lighting control throughout was accomplished by using occupancy sensors in all spaces including storage rooms, corridors, washrooms, offices, gymnasium, library and classrooms. Classrooms had additional dimming and off control as required in teaching spaces. Additionally in classrooms and library, daylight harvesting was utilized to take advantage of sunlight as it entered the space through the generous use of windows. The simple act of controlling the lighting, takes advantage of the need to enhance the learning environment specific to each visual task.

Luminaire Selection and Lighting Design

The most energy efficient light sources were utilized for the specific applications. Also the design was "tuned" such that the correct luminaire was provided for the specific task. MCW/AGE Consulting Professional Engineers' lighting design incorporated the latest research that determined that the greatest energy savings in lighting design will come as a result of application specific lighting!

The approach for lighting was to utilize the efficiency of T5 54W luminaires with electronic ballasts for most applications. To accomplish this, spacing and type of luminaires chosen was challenging to meet the specific requirements to each room and space of the school. Single lamp direct/indirect cable hung linear luminaires were used in classrooms which had generous ceiling height and spacing to create a glow off of the act for muted and even illumination.

Music Room Luminaires

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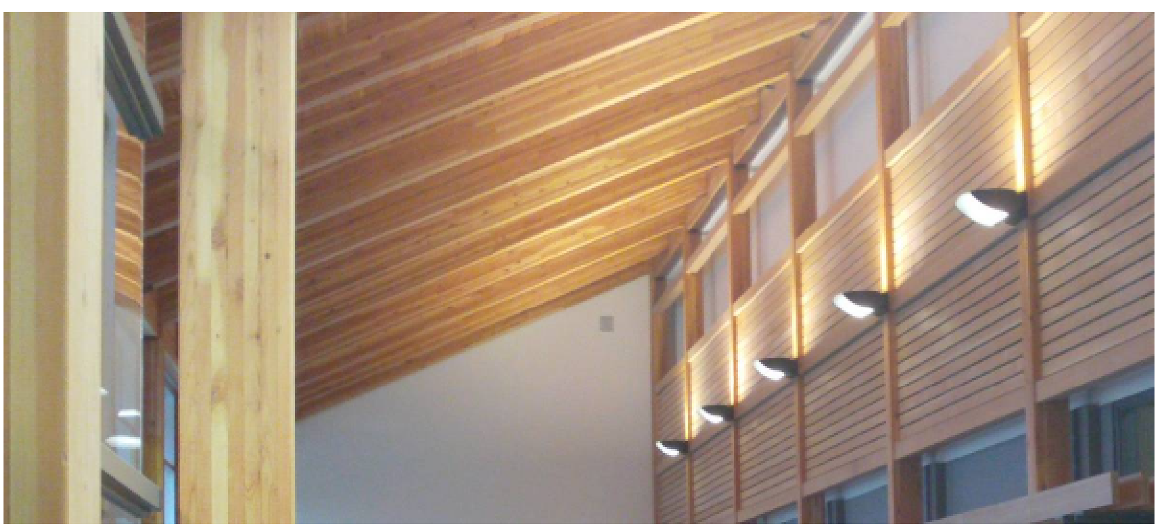
Corridor luminaires were single lamp 1x4 recessed indirect with generous spacing. Gymnasium luminaires were a nominal amount of 6-lamp T5 54W high bay hung at a high elevation for consistent illumination. The remaining areas were a combination of T5 54W linear and minimal use of 26 and 13 watt CFL and 50W MR-16 in recessed pots for entrances, display and accent lighting.

Library luminaires were a combination of 42W CFL pendants and 26W recessed pots to illuminate the work surfaces and high architectural ceilings.

The student commons area was illuminated with a minimal amount of indirect 400W metal halides as to showcase the high ceilings and to reflect down onto the floor surface.

Library Luminaires



Student Commons Area Luminaires

Additional Features

"Smart Board" Technology

Each classroom was fitted with new, interactive "smart boards" which enable the teacher to share multimedia information with the students. The controls and interface for each board is incorporated into the teacher's desk eliminating unsightly and dangerous cords and equipment on the floor.

Sound Field Systems

Each classroom employs a wireless voice amplification system which allows the teacher's voice to be heard clearly within all areas of the classroom. This is further enhanced by the ventilation systems relatively noise-free operation.

Music Room Acoustic Design

Special acoustic criteria were taken into account with the design of the band room. MCW/AGE's in house Acoustic Engineers utilized acoustic modeling software to design and ensure that the acoustic quality of the rehearsal environment exceeded the expectations of the user group. The result is a musical learning space which is second to none at this level, in the region.

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